XXIII.

ON THE INFLUENCES OF TEMPERATURE UPON THE SENSITIVENESS OF THE PHOTOGRAPHIC DRY PLATE. BY J. JOLY, D.Sc., F.R.S.

[Read DECEMBER 20; Received for Publication DECEMBER 22, 1893; Published FEBRUARY 17, 1894.]

THE fact that a photographic plate loses in sensitiveness at low temperatures has already been the subject of experiment. But I am not aware of any experiments beyond those of Abney and Dewar, which were, so far as I can learn, confined to exhibiting the broad fact of the loss of sensibility. Many practical photographers have also, I believe, been aware of the fact from every-day observation.

Some couple of months ago, being then in ignorance of previous observations on the subject, I made experiments upon an Edwards' isochromatic plate and upon a Wratten fast plate. The sensitive plate was backed, one-half with a poultice of solid carbonic acid, just made into a paste with ether; the other half with a poultice of hot water in flannel. It was, in this state of unequal heating, exposed behind a double layer of thick plate-glass to a gas flame. Upon development, the cold half showed but little light-action; the hot was strongly affected. The double window of plate-glass is essential to keep moisture from depositing and obscuring the cold half. A thin piece of glass is cooled so quickly that it obscures before there is time to expose it. The naked plate rapidly becomes frosted on the cold half.

In this experiment I observed that the effect was more marked upon the isochromatic than upon the plain silver bromide plate. It appeared of interest to find if this loss of sensitiveness could be traced to a loss of activity of the Eosin sensitizer to rays of low refrangibility, thus accounting for the more marked effect upon the isochromatic plate.

To investigate this point, I modified a quarter-plate printing frame, so that a plate might be divided into a hot and cold area

longitudinally by poultices, as before described. Upon this the spectrum was formed, from an electric arc, of such dimensions as nearly to extend the full width and length of the plate.

When an isochromatic plate (Edwards') was exposed for a few seconds to the spectrum and developed, it was found that the warm half of the plate showed the usual appearance: strong over the violet and blue, with a weak region in the blue-green (between F and E), and again a vigorous action in the green and yellow-green (between E and D), fading off gradually to the orange-red. This green-yellow sensitiveness is well known to be especially the result of the action of the dye.

On the cold half of the plate, over the violet and blue regions, there was an equal, or very nearly equal, density to that obtaining on the warm half; but all beyond, beginning at the weak region, E–F, and extending to the limit of sensibility, there was a most marked and striking loss of sensibility. Over the weak region there had been no action, or very little; the dense band marking the green-yellow was weakened and narrowed, showing, however, no shifting, and the yellow and orange again were almost without density.

Some ordinary gelatino-bromide plates (Wratten's and Cadett's) were next tried. In the case of these the hot and cold regions did not exhibit so marked a difference. The warm extended, indeed, further beyond F towards E, and there was a slightly inferior density all over the cold spectrum. I am not perfectly sure if this last is a real effect, for some stray light and fogging introduce uncertainty as to whether this may not be—in some degree at least—due to the inferior sensibility between E and F. For such rays in the stray light would be inactive over the cold, and active over the warm halves of the plate. The most marked effect is, however, in this case also towards the less refrangible rays.

It remains to consider how these results may be interpreted in connexion with theories of photo-chemical action and the action of the special sensitizers.

In the first place, we might consider that the deprivation of heat simply affected the fundamental silver bromide molecule, rendering it less resonant to the long wave-lengths, and hence affecting the photo-reduction on the plain gelatino-bromide plate in so far as this is ordinarily sensitive to long wave-lengths, and

affecting the dyed plate the more seriously, as this is prepared to use the long wave-lengths through the intervention or aid of the dye stuff. The experiments, in fact, revealed that, save for the survival of some activity along the special dense band on the green, the ortho-plate was virtually reduced by cold to the limits of sensitiveness of the undyed plate.

While I am inclined to think that the silver bromide molecule is in some degree affected as above, I do not think the experiments on the gelatino-bromide plate prove that it alone is affected in the orthochromatic plate. On the view (favoured by Abney) that the sensitizing action of the dye is a chemical one, started into operation by a photo-chemical change in the dye, it appears to me very probable that the experiments are, in fact, only one more example of the already long series of chemical actions known to be dependent upon temperature for their activity. Possibly, too, the initial photo-chemical action upon the dye is reduced in intensity at low temperatures. In short, the events set in operation by the light waves are complex, and all concerned with molecular stability, whether towards the periodic forces of light or their mutual attractions. It is most probable that molecular stability towards either action is dependent on the quantity of energy possessed by the molecular system.

In the experiments described above, care must be taken that the plates have arrived at uniform temperature before development, or quite other effects would arise. With my own arrangements I am, of course, unable to estimate the temperature of the film. It is certainly not nearly so low as that reached by the mixed carbon dioxide and ether (– 81°). With special arrangements, probably, even more marked results could be obtained. Photographs of yellow flowers upon cooled isochromatic plates contrasted with photographs taken on plates at air temperature would show the effects of cold, no doubt, strikingly. In very cold climates isochromatic plates will possess but little advantage over ordinary plates, except they be maintained at a sufficiently high temperature when being exposed. However, the influence of length of exposure has still to be investigated. It might be that long exposure through a medium opaque to the blue and violet light would restore the 'iso'-chromatic quality.